Acorus calamus: A Review on Its Phytochemical and Pharmacological Profile

17

Suhaib Afzal, Mehrose Ayoub, and Weekar Younis Raja

Abstract

By systematizing and analyzing the vigor of potent plant-derived compounds, herbal drugs can assist the exposure of a replacement period of the healthcare system to nurse human diseases within the future. Perception of lore and remedial plants can play a vital role within the utilization and revelation of natural plant resources. *Acorus calamus* is a tall perennial marshland monocot plant, being the member of the family Acoraceae. *A. calamus* habitually known as sweet flag It is also known by different names, including sweet sedge, sweet root, sweet rush, sweet cane, sweet myrtle, myrtle grass, myrtle sedge, gladdon, myrtle flag, flag root, and cinnamon sedge. This medicinal herb is perhaps native to India and located across China, Europe, northern Asia Minor, southern Russia, Japan, northern USA, Sri Lanka, Burma, and Japan. The rhizomes of calamus and aromatic leaves are conventionally employed as a drug and therefore the dried and powdered rhizome features a tangy flavor and is employed as an alternate for nutmeg, cinnamon and ginger for its odor. The rhizomes are examined to have carminative, expectorant, nauseate, nervine, sedative, stimulant, aromatic, anthelmintic, and antispasmodic properties, and also employed for the medicaments of mental ailments, epilepsy, antidiabetic, antioxidant, anticonvulsant, long-term diarrhea, dysentery, glandular and abdominal tumors, fevers, and bronchial catarrh. The prehistoric people of China employed it for constipation and to reduce swelling. In Ayurvedic School of medicine from India, the rhizomes are wont to treat various diseases like bronchitis, fever, asthma, and as a sedative. Indigenous tribes employed it to treat a cough. As a carminative they employed it to make a decoction from it and as an infusion for colic. Perception of lore and

S. Afzal · M. Ayoub · W. Y. Raja (✉)
Department of Pharmaceutical Sciences, School of Applied Sciences and Technology, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir, India

M. H. Masoodi, M. U. Rehman (eds.), *Edible Plants in Health and Diseases*,
https://doi.org/10.1007/978-981-16-4959-2_17

remedial plants can take part in vital role within the utilization and unearthing of natural plant assets. Encyclopedic approach and association are needed to take care of ancient documentation on medicinal plants and utilizing these assets in benefit of citizenry. The present review gives a brief introduction about the medicinal, phytochemical, and pharmacological related aspects of the plant.

Keywords

Acorus calamus · Expectorant · Ayurvedic · Antispasmodic · Aromatic

Abbreviations

Ac	*Acorus calamus*
API	Ayurvedic Pharmacopeia India
BHU	Banaras Hindu University
BP	Blood pressure
CCB	Calcium channel blockade
DPPH	2,2-Diphenyl-1-picrylhydrazyl
ECG	Electrocardiography
GABA	Gamma-amino butyric acid
HDL	High density lipoproteins
HIV	Human immunodeficiency virus
HSV	Herpes simplex virus
IC	Inhibitory concentrations
LDL	Low density lipoproteins
LPO	Lipid peroxidation
MES	Maximal electroshock seizure
OPD	Out patient department
STZ	Streptozotocin
USA	United States of America

17.1 Introduction

During the past decade, herbal medicine gained lot of importance particularly in those developing countries where population depends on conventional specialists, remedial plants for their medical care needs. Besides the availability of modern medicine, herbal medicine retained its significance. With the increasing usage of herbal medicine, issues for their quality and efficacy also increased. Increased profits have forced the researchers to go through various conventional claims. In today's world everyone needs scientific recommendation before making use of the conventional drugs. Thus, information regarding medicinal plant as drug is recommended before its use. The present effort is to review and organize total information till date on *Acorus calamus*, a plant employed in the Indian School of medicine for various reasons. *A. calamus* (sweet flag) is the herbaceous perennial, and it is about 2 m tall (NRCS 2014). Its leaves are like those of Iridaceae. Sweet flag consists of the cluster

of leaves at the base and these leaves arise from the rhizome (NRCS 2014). The leaves are erect and yellowish-brown; the pattern of veination is parallel. By crushing it, fragrant odor is emitted out and that confirms the presence of spadix as shown in Figs. 17.1, 17.2, and 17.3. Besides "sweet flag" and "calamus" some other names include myrtle flag, myrtle sedge, myrtle root, beewort, gladdon, sea sedge, sweet cinnamon, sweet cane, sweet sedge, sweet grass, sweet root, sweet myrtle, and sweet rush (NRCS 2014; Runkel and Bull 2009).

Taxonomy: (Singh et al. 2011a, b)
Kingdom: Plantae
Subkingdom: Tracheobionta
Super division: Spermatophyta
Division: Magnoliophyta
Class: Liliopsida
Subclass: Arecida
Order: Arales
Family: Acoraceae
Genus: *Acorus* L.
Species: *Calamus*

Fig. 17.1 Aerial parts of *Acorus calamus*

Fig. 17.2 *Aerial parts of Acorus calamus*

Fig. 17.3 Aerial parts of *Acorus Calamus*

17.1.1 Habit and Ecology

A. calamus is a robust plant generally growing from tropical to subtropical climates. Sunshine is necessary for the growth of plant and also for drying the harvested rhizome from the plant. Temperature fluctuates from 10 to 38 °C and rainfalls ranging from 70 to 250 cm are the favorable conditions. Plantation should be evaded in places where there's no irrigation possibility. Light alluvial soil of river banks, clayey loams, and sandy loams are the favorable soils where *A. calamus* is usually planted (Chandra and Prasad 2017). It is allocated all over the tropics and subtropics of Sri Lanka and India especially. In marshy places of Himalayas, it grows up to 2000 m altitude (Balakumbahan et al. 2010). It is reported in the districts of Jammu and Kashmir (Sharma et al. 1985), Andhra Pradesh (Rao and Sreeramulu 1985), Karnataka (Malabadi et al. 2007), Himachal Pradesh (Jain and Puri 1994), and in districts of Uttar Pradesh (Srivastava et al. 1997).

Common Names

Sweet flag or calamus (NRCS 2014)

Vernacular Names

Arabic: bach, vaj, vajj

English: calamus, flag root, sweet flag, sweet cane, sweet rush (NRCS 2014; Runkel and Bull 2009)

Hindi: bacc, bach, baj, gora-bach, vasa

Sanskrit: bhadra, bacha, bhutanashini, bodhaniya

Urdu: waj-e-turki, bacha

Kashmiri: vai-gandur, vai

Habitat: *A. calamus* is a subaquatic herbaceous perpetual herb

17.1.2 Morphology

Leaves. Leaves are scented, lineal, upright, and cutlass, up to 1 m in length and 1–2 cm in width. The midvein is usually off center (Motley 1994).

Stem. The stem is resilient, creased, subterranean rhizome that ranges in length 10–35 cm and 1–2 cm in diameter, whitish-pink in color within, with distant nodes and internodes. They are very aromatic and bitter in taste (Motley 1994).

Roots. Roots are white, rarely branched, and produced in rows on the anterior side of crawling rhizome.

Inflorescence. The inflorescence comprises of a spathe and spadix.

Flowers. Flowers are perfect and hypogynous; green, densely crowded on a cylindric, sessile, spadix.

Fruit. The fruit is a multi-seeded mucilaginous berry (Fernald 1950).

Seeds. Seeds are oblong in shape (Motley 1994)

17.1.3 History and Folklore

A. calamus has a long and an interesting history. The name "Acorus" has descended from the Greek word *Acoron*, employed by Dioscorides, which in turn was descended from *Coreon* meaning "pupil" as it was employed in the treatment for inflammation of eye (Grieve 1971). Sweet flag has abundant chronicled history in the Indian and Chinese civilization. In Indian markets, sweet flag was introduced by Celsius without any impediment. In India, for centuries it was used as the significant remedial aid for stomach disorders and colic (Barton and Castle 1877). The rhizome of the plant was employed to cure diarrhea, dysentery, and asthma. It was believed by the Romans, Chinese, and the Arabians that the rhizome of *A. calamus* has aphrodisiac property (Connell 1965). They ate it raw with bread and boiled vegetables "for carnal desires" because it was said that this plant "excites the carnal cupidity for 'Venus'" (Wedeck 1960). Sweet flag was distributed from its native region to Europe by Mongols in eleventh century and is part of the herbs stated in *Exodus*. Soon, *A. calamus* became "symbol of invasion "of Mongols and was known as 'Mongolian poison'" as they planted them wherever they settled, because they believed *A. calamus* purified water. Austrian Botanist, Clusius acquired rhizome from Asia Minor, and planted it in Vienna and thus the first record of sweet flag cultivation was in 1954. In England, it was planted by Gerard in 1956 and was subsequently transferred to Belgium and France. It was used in North America and Europe as a panacea. Chinese believed that it was also used to hallucinate or "see spirits." *A. calamus* was used as breath freshener, room refresher, insect repellant, and American tribes inhaled it to strive fatigue and hunger. The diseases and ailments it was used to cure are many. It was also used to bedeck houses both for aesthetic and magic purposes (Dobelis 1986; Ott 1975). Sweet flag was soon cultivated by numerous civilizations right through both the hemispheres.

17.1.4 Traditional Medicinal Uses

The rhizome of *A. calamus* has been found to possess numerous medicinal uses in the school of Ayurvedic medicine. The rhizome of *A. calamus* has anthelmintic, aphrodisiac, carminative, antispasmodic, diuretic, laxative, emetic, expectorant, bitter tonic, stimulant, and aromatic properties (Mukherjee et al. 2007a; b). It is also employed in the therapy of many diseases such as mental disorders (like schizophrenia), epilepsy, and memory disorders. Rhizome is also employed in the therapy of long-term diarrhea and dysentery, bronchial catarrh, fever, colic, cough (Rao 1983), asthma, as well as abdominal and glandular tumors (Kirtikar and Basu 1935). The skin of rhizome is said to have hemostatic property (Mukherjee et al. 2007a, b). The roots of *A. calamus* are used as antipyretic and antitussive (Dobriyal et al. 1997). The granulate form of sweet flag brings about the emesis when administered with the warm salt water (Imam et al. 2013). In powders, balms, enemas, pills, and even also in ghee preparations, rhizomes of *A. calamus* are used

(Kirtikar and Basu 2001). *A. calamus* also helps in removing excessive fats from the body (Rajput et al. 2014).

17.2 Pharmacological Actions

17.2.1 Antispasmodic Activity

The antispasmodic activity was found in the oil of *A. calamus* rhizome. The oil extracted from the rhizome of *A. calamus* obstructed the peristalsis of the intestines in rabbits and dogs by exhibiting its effect on the involuntary muscle tissue (Chopra et al. 1954). Several experiments were performed like lung perfusion and isolated tracheal chain experiments in which volatile oil was detected to be of better therapeutic use than alcohol and aqueous extract (Bose et al. 1960). Against various spasmogens, α-asarone and its volatile oil exhibited antispasmodic and relaxant effect. On extracted guinea pig ileum and analgesic activity in mice, hypothermia, and overall behavioral effect, the ethanolic extract of rhizome showed antispasmodic activity (Bhakuni et al. 1988). Antispasmodic activity was also detected in the raw extricate of *A. calamus*. The raw extricate of *A. calamus* induced obstruction of impulsive and high K^+ (80 mM) and caused contractions with respective EC_{50} values of 0.13 ± 0.04 and 0.42 ± 0.06 mg/mL, thus showing spasmolytic property, moderated possibly through calcium channel blockade (CCB) in the isolated rabbit jejunum preparations (Gilani et al. 2006).

17.2.2 Anthelmintic Activity

In vitro anthelmintic activity against the *Ascaris lumbricoides* was shown by the alcohol extract of *A. calamus* (Kaleysa Raj 1974). The exposure with the volatile oil of *A. calamus* within the time limit of 5 min revealed that the immensity of the periodic contractions of *Ascaris lumbricoides* was inhibited. Complete paralysis was caused within 25 and 5 min respectively when the phenolic and nonphenolic fractions of the oil were examined independently (Chaudhari et al. 1981). Another study states that the essential oil was also effective against *Meloidogyne incognita* (Singh et al. 1991). Within the range of 5–11 years of age, an interventional study was performed on about 147 children having roundworm infestation by Sharma et al. (1985). *A. calamus* powder weighing 250 g was administered thrice daily for 3 days. When the outcome was evaluated, it showed that in 17% no change was seen, while 83% were completely cured.

17.2.3 CNS Depressant Activity

Tripathi and Singh (1995) carried out a clinical trial of 50 cases of depression at OPD of Sir Sunderlal (SS) Hospital at Banaras Hindu University (BHU), Varanasi. The

patients were administered 500 mg *A. calamus* in a dose of two tablets, thrice a day, after meal with water. It showed a great depression and better rehabilitation when given for 6 weeks. The notable enhancement in evaluation is established on grading of manifestation on Hamilton depression grading scale. The apprise of enhancement before and after therapy was remarkable. Impulsive electrical property and monoamine levels of the brain were studied in the ethanolic extract of *A. calamus*. There was an elevation in the α activity with an elevation in the norepinephrine level in the cerebral cortex when rats were given the dose of *A. calamus*, but in midbrain and cerebellum levels were decreased when electrogram recording was revealed. In the same way, in caudate nucleus and midbrain increased levels of dopamine were recorded but decreased in the cerebellum. In different brain regions, *A. calamus* showed depressive actions by altering brain monoamine levels and by changing electrical activity (Hazra and Guha 2003).

17.2.4 Antidiarrheal Activity

According to the study, when mice were given the aqueous and methanolic decoction of *A. calamus* rhizome, there was a decrease in the total number of excreta, number of wet excreta, and total weight of excreta. Against the castor oil–induced diarrhea, methanolic decoction was more successful than aqueous plant derivative. Induction time of diarrhea and total weight of excreta were decreased notably by the methanolic extract of AC (Shoba and Thomas 2001). The result obtained establishes the effectiveness of these plant extracts as antidiarrheal agents.

17.2.5 Action on Respiratory System

The crude extricate of *A. calamus* has been found to be very effective for the respiratory ailments caused by the presence of peculiar association of airways-relaxant elements such as papaverine-like duplex obstruction of calcium channels and phosphodiesterase in the hexane fraction (Shah and Gilani 2010) and anticholinergic, rolipram—like phosphodiesterace-4 inhibitor in the ethyl acetate fraction (Jabbar and Hassan 2010). In patients having moderate to severe bronchial asthma, a clinical trial was done for 2–4 weeks in which the patients had to chew the fresh rhizomes of *A. calamus*. The anti-asthmatic potential was discovered in the rhizome of *A. calamus* without any aftereffects (Rajasekharan and Srivastava 1977). The noticeable or major effect was observed when small pieces of rhizome were given to asthmatic patients in curing of bronchospasm without any aftereffects (Chandra 1980).

17.2.6 Action on Cardiovascular System (CVS)

Essential oil of *A. calamus* has been studied for its activities of decreasing blood pressure (Chopra et al. 1954). After two-stage coronary ligation in dogs, the essential

oil of *A. calamus* showed the activity like quinidine which is the isomer of quinine to tackle atrial fibrillation, atrial flutter, and ventricular arrhythmias. It qualitatively resembled quinidine in isolated rabbit auricles as it extended conduction time and refractory period (Madan et al. 1960). Also, 50% alcohol extricate of *A. calamus* exhibited a dose-dependent hypotensive action on dog blood pressure (Moholkar et al. 1975). Antiarrhythmic properties and negative inotropic were also reported in its essential oil. Hypotensive activity was reported in anesthetized dogs and on frog heart perfusion experiments. β-Asarone revealed cardiac depressant activity (Arora 1965; Mamgain and Singh 1994). A total of 45 patients suffering from ischemic heart disease were shortlisted for a clinical trial from the OPD of SS Hospital, BHU. When the various groups were treated with the *A. calamus* extracts, they showed the remarkable improvements in the treatment of various diseases like dyspnea, chest pain, decreasing serum cholesterol level, decreasing serum low-density lipoproteins (LDL), increasing serum high-density lipoproteins (HDL), and improving ECG.

17.2.7 Anticonvulsant Activity

The methanol extricate of *A. calamus* manifested anticonvulsant property, at the doses of 100 and 200 mg/kg, successfully by potentiating the effect of gamma-aminobutyric acid (GABA) pathway in the nervous system (Jayaraman et al. 2010). The purified rhizome whose purification is done by boiling it in cow's urine as recommended in the *Ayurvedic Pharmacopeia of India* (API) before its curative use was analyzed in a maximal electroshock (MES) seizure model and the standard drug used was phenytoin. The crude rhizome of *A. calamus* exhibited eminent anticonvulsant activity in rats by reducing the interval of the tonic extensor while the processed rhizome when it was raw showed better therapeutic activity (Bhat et al. 2012). Antiepileptic property has also been reported in the oil of the *A. calamus* isolated from its rhizome. It was tested in adult albino mice where it efficiently restrained seizures in maximal electroshock seizure (MES) test (Khare and Sharma 1982).

17.2.8 Anticancer Activity

By affinity chromatography, two lectins were purified from the two species of AC which showed potent antimitogenic activity toward lymphocytes of human and mouse splenocytes. The two lectins which were purified showed the inhibitory action to some extent on a B-cell lymphoma,WEHI-279, and notably obstructed the magnification of murine macrophage cancer cell line, that is J774 (Bains et al. 2005). According to studies, β-asarone found in calamus oil also attributed to the anticancer activity (Palani et al. 2010). The inhibited proliferation induced by mitogen phytohemagglutinins was concluded from examining the ethanolic extract of AC rhizome which showed the in vitro anticellular activity of the ethanolic extricate. AC extract inhibited production of tumor necrosis factor-α, nitric oxide,

interleukin-2, and spreading of various cell lines of mouse and human origin (Mehrotra et al. 2003).

17.2.9 Antibacterial Activity

The antibacterial property of *A. calamus* was detected in its leaf and rhizome part. When the methanolic solution of *A. calamus* was taken, it showed strong antibacterial property toward the bacterial strains of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *and Klebsiella pneumonia* (Pokharel et al. n. d.). β-Asarone compound obtained from the third fraction of the raw methanolic solution of *A. calamus* has been revealed to have the highest inhibition toward *S. aureus*, *E.coli* strain at various concentrations (Manikandan et al. 2010). By an extract of rhizome, growth of gram-negative bacteria was significantly inhibited. *B. subtilis* and *Mycobacterium* spp. were easily vulnerable to calamus oil (Radušene et al. 2007).

17.2.10 Antifungal Activity

From the raw methanolic extract of *A. calamus* rhizome the β-asarone compound obtained was primarily responsible for the fungi toxicity (Saxena et al. 1990). β-Asarone possessed antifungal property in opposition to the yeast strain of *Saccharomyces cerevisiae*, *Cryptococcus neoformans*, *and Candida albicans* (Singh et al. 2011a, b). In the alcoholic extract of *A. calamus*, antifungal effect was studied toward the *Penicillium selenium, Aspergillus niger*, and yeast *Saccharomyces* (Vashi and Patel 1987).

17.2.11 Antiviral Activity

Alcoholic extract of the rhizome of *A. calamus* showed remarkable results in case of the Herpes simplex virus HSV-1 and HSV-2 respectively (Badam 1995).

17.2.12 Anti-HIV Activity

It was observed that the rhizome of *A. calamus* showed obstruction toward HIV-1 reverse transcriptase. In addition, 50% inhibitory concentrations (IC50) were reported to be the efficacy of the anti-HIV-1RT activity. This showed that the hexane crude extracts of *A. calamus* contained potent activity against HIV-1RT (Silprasit et al. 2011).

17.2.13 Antipyretic Activity

Methanolic extract and aqueous dichloromethane of *A. calamus* were tested for antipyretic activity. The dichloromethane and methanol extract reduced pyrexia. The activity was dependent upon time and concentration. The results exhibit the use of *A. calamus* in traditional medicine and contain the constituent which can be used as an antipyretic (Nethengwe et al. 2012).

17.2.14 Analgesic Activity

Analgesic activity at a dose of 500 and 250 mg/kg body weight was tested toward the methanolic extricate of *Oroxylum indicum* and *A. calamus*. At a dose of 25 mg/kg this was also tested toward the standard drug named diclofenac sodium. Assessed by acetic acid-induced writhing method, five adult Swiss albino mice were taken for study. Inhibited writhing reflex of methanolic extract of *A. calamus* was seen at the dose of 250 and 500 mg/kg body weight by 30.77 and 39.86%. So, the outcome of the current article indicated that the methanol extract of *A. calamus* roots possess analgesic activity on mice (Hosen et al. 2011).

17.2.15 Sedative Activity

The volatile oils of the *A. calamus* enhance the sedative activity of pentobarbitone in mice. The active constituent accountable for this activity is found in the various fractions of the oil which were either hydrocarbon fraction or an oxygenated fraction (Dandiya et al. 1959; Mukherjee et al. 2007a; b). With ethanol, hexobarbital, pentobarbital, and the steam volatile fraction in mice prolonged the sleeping time (Mukherjee et al. 2007a, b). In the volatile fraction of the petroleum ether extricate, the highest sedative property was recorded (Dandiya and Cullumbine 1959).

17.2.16 Antioxidant Activity

Antioxidant property was found in the rhizome of *A. calamus* and the compounds mainly responsible for this activity were the phenolic compounds. This property was examined by radical scavenging assay 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Ahmed et al. 2009). The in vitro antioxidant activity by DPPH is dose concentration dependent and at the three different concentrations (0.01, 0.1, and 0.2 g/mL) DPPH scavenging property was reported and the maximum activity was recorded at the concentration of 0.2 g/mL (Govindarajan et al. 2003). The antioxidant activity was also reported by superoxide radical scavenging assay, nitric oxide scavenging assay, ferrous chelating assay, phosphomolybdenum assay and reducing power assay. In the acetone extricate, maximum antioxidant effect was seen followed by the aceto-nitrile and methanol, while the aqueous extract was dose dependent and possessed poor antioxidant activity (Bahukhandi et al. 2013). Aqueous extract showed

maximum antioxidant effects in metal ion chelation, lipid peroxidation (LPO), and DPPH assay (Karthiga et al. 2016; Manju et al. 2013). Thus, the outcome portrayed that *A. calamus* extracts possessed metal chelating activity, free radical scavenging property, and reducing power.

17.2.17 Antidiabetic Activity

A. calamus has the ability to be employed in the therapy of diabetes (Wu et al. 2009). The ethyl acetate of *A. calamus* was assessed in the streptozotocin (STZ)-induced and diabetic (db/db) mouse, the diabetic effect was evaluated from this. From the radix of the *A. calamus*, four fractions were obtained which showed a noticeable reduction in the blood glucose levels, low concentration of the lipids in the blood, and other effects by the insulin-sensitizing mechanism, and hence the *A. calamus* can be used in the treatment of diabetes (Kedar n.d.).

17.2.18 Insecticidal Activity

When the essential oil of the *A. calamus* was tested against the houseflies *Musa domestica*, it showed the insecticidal activity (Singh and Mehta 1998). Against the housefly *Musca nebulo* and *Culex fatigans* the solvents extract of the *A. calamus* rhizome were found to be toxic. Against the bugs, lice, and moths, powdered form of *A. calamus* rhizome was found to be effective (Subrahmanyam 1949); repellant property was also found against *Callosobruchus chinensis*, which is a plant beetle (Khan 1986). The inhibition of the interstitial property of the *Dysdercus koenigii* which is the instar larvae was found in the oil of *A. calamus*. The chemical constituent found in the *A. calamus* β-asarone formed a novel kind of antigonadal agent because of its antigonadal function which may be a novel and secure procedure toward the insect restrain (Saxena et al. 1977). When essential oil was employed as emulsified foliage sprays against the third instar larvae of *Spodoptera litura*, antifeedant and growth inhibitory effects were observed (Koul 1987) and also used in managing the stored grain insect *Spodoptera* (Agarwal et al. 1973). Sterility in the male houseflies was observed when the oil vapors of *A. calamus* were used. It showed the morphological change in the ovaries of *Thermobia domestica* (Saxena and Rohdendorf 1974; Mathur and Saxena 1975) (Figs. 17.3 and 17.4).

17.3 Phytochemistry

Phytochemical studies of *A. calamus* have reported the presence of phenylpropanoids, sesquiterpenoids, monoterpenes, xanthone glycosides, triterpenoid saponins, alkaloids, triterpene glycosides, steroids/sterols, amino acids, and fatty acids (Table 17.1). Sections 17.3–17.3.8 exhibit the chemical structures of the compounds

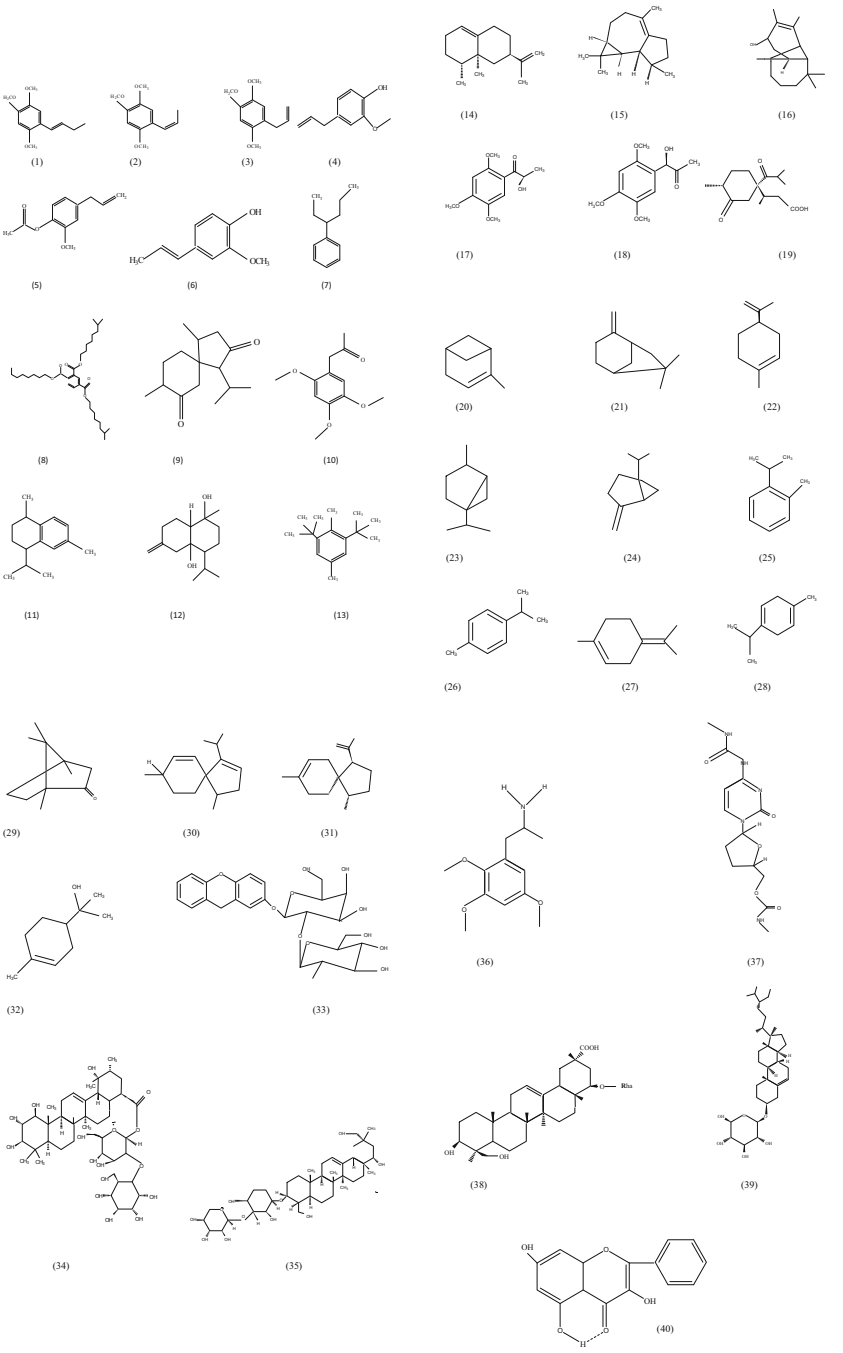

Fig. 17.4 Chemical structures of the major chemical constituents of *Acorus calamus*

Table 17.1 Different phytochemicals of *Acorus calamus*

Classification	Compound no.	Chemical ingredient	Parts/extract	References
Phenylpropanoids	1	α-Asarone	Rhizome/n-hexane, aqueous, methanol, ethanol	Mukherjee (2002), Nigam et al. (1990), Kumar et al. (2010), Lee et al. (2011), Padalia et al. (2014)
	2	β-Asarone		
	3	γ-Asarone		
	4	Eugenol	Rhizomes aqueous extract	Mukherjee (2002), Nigam et al. (1990), Kumar et al. (2015)
	5	Eugenyl acetate		
	6	Isoeugenol		
	7	Calamol	Rhizome aqueous	Patra and Mitra (1981)
	8	Acorin	Rhizome/chloroform	
Sesquiterpenoids	9	Acorone	Rhizome Hydro alcoholic	Zaugg et al. (2011)
	10	Acoramone	Rhizome/aqueous	Yao et al. (2018)
	11	Calamene		Mukherjee (2002), Nigam et al. (1990), Kumar et al. (2015)
	12	Calamenenol		
	13	Calameone		
	14	Valencene		Ozcan et al. (2002)
	15	Viridiflorene		
	16	Vulgarol B		Haghighi et al. (2017)
	17	Tatarinoid A	Rhizome/95% alcohol	Yao et al. (2018)
	18	Tatarinoid B		
	19	Acoric acid	Rhizome/ethanol	Li et al. (2017)
Monoterpenes	20	α-Pinene	Rhizomes, roots Aqueous	Mukherjee (2002), Nigam et al. (1990), Kumar et al. (2015), Ozcan et al. (2002)
	21	β-Pinene		
	22	Limonene	Roots (aqueous) Leaves	Ozcan et al. (2002), Haghighi et al. (2017)
	23	Thujane		Raja et al. (2009)
	24	Sabinene		Ozcan et al. (2002)

	25	o-Cymol		Haghighi et al. (2017)
	26	p-Cymene		Lee et al. (2011), Ozcan et al. (2002), Haghighi et al. (2017)
	27	α-Terpinene		Haghighi et al. (2017)
	28	γ-Terpinene	Rhizomes, roots Aqueous	
	29	Camphor	Rhizome, roots, leaves, /aqueous, hexane	Ozcan et al. (2002), Radusviene et al. (2007)
	30	α-Acoradiene	Roots aqueous	Ozcan et al. (2002)
	31	β-Acoradiene		
	32	α-Terpineol		
Xanthone glycosides	33	4,5,8-Trimethoxy-xanthone-2-O-β-D-glucopyranosyl (1–2)-O-β-D-galactopyranoside	Rhizome/ethanol	Rai et al. (1999)
Triterpenoid saponins	34	1β,2α,3β,19α-Tetrahydroxyurs-12-en-28-oic acid-28-O-{(β-D-glucopyranosyl (1–2)}-β-D galactopyranoside	Rhizome/ethanol	Rai et al. (1998)
	35	3-β,22-α-24, 29-Tetrahydroxolean-12-en-3-O-{(β-Darabinosyl (1,3)}-β-D-arabinopyranoside		
Alkaloids	36	Trimethoxyamphetamine, 2,3,5 and Pyrimidin-2-one	Rhizome/ethanol	Kumar et al. (2010)
	37	4-[N-methylureidol]-1-[4methylamino carbonyloxy methyl]		
Triterpene glycosides	38	22-[(6-deoxy-α-L-rhamnopyranosyl) oxy]-3, 23-dihydroxy-, methyl ester (3β, 4β, 20α, 22β)	Root, rhizome/ethyl ether	Wu et al. (2007)
Steroids/sterols	39	β-Daucosterol		Wu et al. (2007)
Flavones	40	5,7-Dihydroxyflavanol		Stahl and Keller (1981)

from *A. calamus*. The Chemical structures of the major chemical constituents of *Acorus Calamus as shown in* Fig. 17.4

17.3.1 Phenylpropanoids

A number of phenylpropanoids have been extracted from the plant. Some of the phenylpropanoids extracted are α-asarone(1), β-asarone (2), γ-asarone (3) (Mukherjee 2002; Nigam et al. 1990), eugenol (4), eugenyl acetate (5), isoeugenol (6) (Kumar et al. 2015; Mukherjee 2002; Nigam et al. 1990), calamol (7), acorin (8) (Padalia et al. 2014).

17.3.2 Sesquiterpenoids

Phytochemical study revealed the number of sesquiterpenoids in the plant such as acorone (9) (Zaugg et al. 2011), acoramone (10) (Yao et al. 2018), calamene (11), calameone (12), calamenenol (13) (Kumar et al. 2015; Mukherjee 2002; Nigam et al. 1990), valencene (14), viridiflorene (15) (Özcan et al. 2002), vulgarol B (16) (Haghighi et al. 2017), tatarinoids A & B (17, 18) (Li et al. 2017), acoric acid (19) (Yao et al. 2018).

17.3.3 Monoterpene

Reported monoterpenes in the plant are α-pinene (20), β-pinene (21) (Kumar et al. 2015; Mukherjee 2002; Nigam et al. 1990; Özcan et al. 2002), limonene (22) (Haghighi et al. 2017; Özcan et al. 2002), thujane (23) (Raja et al. 2009), sabinene (24) (Özcan et al. 2002), O-cymol (25) (Haghighi et al. 2017), p-cymol (26) (Haghighi et al. 2017; Lee et al. 2011; Özcan et al. 2002), α-terpinene (27), γ-terpinene (28) (Haghighi et al. 2017), camphor (29) (Özcan et al. 2002; Radušienė et al. 2007), α-acoradiene (30), β-acoradiene (31), α-terpineol (32) (Özcan et al. 2002).

17.3.4 Xanthone Glycosides

4,5,8-Trimethoxy-xanthone-2-O-β-D-glucopyranosyl (1–2)-O-β-D-galactopyranoside was newly reported from the plant (33) (Rai et al. 1999).

17.3.5 Triterpenoid Saponins

The compounds belonging to this category are 1β, 2α, 3β, 19α-Tetrahydroxyurs-12-en-28-oic acid-28-O-{(β-D-glucopyranosyl (1–2)}-β-D galactopyranoside (34) and

3-β,22-α-24, 29-Tetrahydroxolean-12-en-3-O-{(β-D-arabinosyl (1,3)}-β-D-arabinopyranoside (35) (Rai et al. 1998).

17.3.6 Alkaloids

Alkaloids reported from the plant are trimethoxyamphetamine, 2,3,5 (36) and pyrimidin-2-one, 4-[N-methylureidol]-1-[4methylamino carbonyloxy methyl] (37) (Kumar et al. 2010).

17.3.7 Triterpene Glycoside

22-[(6-Deoxy-α-L-rhamnopyranosyl)oxy]-3, 23-dihydroxy-, methyl ester, (3β, 4β, 20α, 22β)(38) is the reported triterpene glycoside from the *A. calamus* (Wu et al. 2007).

17.3.8 Steroids/Sterols

β-Daucosterol (39) (Wu et al. 2007) is reported from the plant.

17.3.9 Flavones

5,7-Dihydroxyflavanol(40) (Galangin) is extracted constituent isolated from the *A. calamus* (Stahl and Keller 1981).

17.4 Conclusion

In the current review, we have made an effort to survey and contribute the utmost information of pharmacognostical with history and geographical distribution, traditional claims, phytochemical and pharmacological information of *A. calamus*, a remedial herb employed in the Indian school of medicine. Study of literature displayed the presence of triterpenoid, sesquiterpenoids, alkaloids, steroids, and glycosides in various parts of this plant were discovered. *A. calamus* showed the blood pressure lowering/vasomodulator activity with other important activities. The plant showed anticonvulsant, antipyretic, analgesic, antitussive, and antitumor activities. Increased blood pressure and tumor asserts millions of lives every calendar year on worldwide basis which is predominantly due to proliferated resistance to preexisting drugs. In spite of the fact that drugs presently in use for the treatment of the same were initially extracted from the plants, further search for extraction and recognition of new drugs is need of time. The plant has strong antitumor and vasomodulator claims and may lead to antitumor and vasomodulator compounds.

The ethnopharmacological procedure employed in exploring the new drugs for such compounds from such plants emerges to be pleasant in comparison to the arbitrary testing procedure. However, a favorable procedure is required to employ these agents as model for plotting new derivatives with improved properties. This review will undoubtedly will come to the aid for the researchers and practitioners, handling with this plant, to know its nature and properties. Due to its indispensable value, at last it is not incorrect to portray that this plant is magnificent conventional plant.

References

Agarwal DC, Deshpande RS, Tipnis HP (1973) Insecticidal activity of Acorus calamus on stored gram insects. Pesticides 7:21

Ahmed F et al (2009) In vitro antioxidant and anticholinesterase activity of *Acorus calamus* and Nardostachys jatamansi rhizomes. J Pharm Res 2(5):830–883

Arora RB (1965) Cardiovascular pharmacotherapeutics of six medicinal plants indigenous to India. Award Monograph Series No. 1. Hamdard National Foundation, New Delhi, pp 421–450

Badam L (1995) In vitro studies on the effects of Acorus calamus extract and b-asarone on Herpes viruses. Deerghayu Int 11:16–18

Balakumbahan R, Rajamani K, Kumanan K (2010) Acorus calamus: an overview. J Med Plant Res 4(25):2740–2745

Bahukhandi A, Rawat S, Bhatt ID, Rawal RS (2013) Influence of solvent types and source of collection of total phenolic content and antioxidant activities of Acorus calamus L. Natl Acad Sci Lett 36:93–99

Bains JS, Dhuna V, Singh J, Kamboj SS, Nijjar KK, Agrewala JN (2005) Novel lectins from rhizomes of two Acorus species with mitogenic activity and inhibitory potential towards murine cancer cell lines. Int Immunopharmacol 5:1470–1478

Barton BH, Castle T (1877) The British flora medica. Chatto and Windus, Piccadilly, London, pp 171–173

Bhakuni DS, Goel AK, Jain S, Mehrotra BN, Patnaik GK, Prakash Y (1988) Screening of Indian plants for biological activity, Part XIII. Indian J Exp Biol 26:883–904

Bhat SD, Ashok BK, Acharya RN, Ravishankar B (2012) Anticonvulsant activity of raw and classically processed Vacha (Acorus calamus Linn.) rhizomes. Ayu 33:119–122

Bist MK, Badoni AK (1990) Araceae in the folk life of the tribal populace in Garhwal Himalayas. J Eco Bot Phytochem 1:21–24

Bose BC, Vijayvargiya R, Saiti AQ, Sharma SK (1960) Some aspects of chemical and pharmacological studies of Acorus calamus Linn. J Am Pharm Assoc 49:32–34

Chandra P (1980) A note on the preliminary study on Acorus calamus L. in the treatment of bronchial asthma. J Res Ayurveda Siddha 1:329–330

Chaudhari GN, Kobte CK, Nimbkar AY (1981) Search for anthelmintics of plant origin: activities of volatile principles of Acorus calamus against Ascaris lumbricoides. Ancient Sci Life 1:103–105

Chandra D, Prasad K (2017) Phytochemicals of Acorus calamus (Sweet flag). J Med Plant Stud 5(5):277–281

Chopra IC, Jamwal KS, Khajuria BN (1954) Pharmacological action of some common essential oil bearing plants used in indigenous medicine. Part I. Pharmacological action of acoruscalamus, curcumazedoaria, xanthoxylumalatum and Angelica archangelica. Indian J Med Res 42:381–384

Connell C (1965) Aphrodisiacs in your garden. Taplinger Publishing Co., New York, pp 95–96

Dandiya PC, Cullumbine H (1959) Studies on Acorus calamus III. Some pharmacological actions of the volatile oil. J Pharmacol Exp Ther 125:353–359

Dandiya PC, Baxter RM, Walker GC, Cullumbine H (1959) Studies on Acorus calamus. Part II. Investigation of volatile oil. J Pharm Pharmacol 11:163–168
Dobelis IN (1986) Magic and medicine of plants. The Reader's Digest Association, Inc., Pleasantville, NY, p 314
Dobriyal RM, Singh GS, Rao KS, Saxena KG (1997) Medicinal plant resources in Chhakinal watershed in the Northwestern Himalaya. J Herb Species Med Plant 5:15–27
Fernald ML (1950) Gray's manual of botany, 8th edn. American Book Co., New York, p 385
Gilani AU, Shah AJ, Ahmad M, Shaheen F (2006) Antispasmodic effect of Acorus calamus Linn. is mediated through calcium channel blockade. Phytother Res 20:1080–1084
Govindarajan R, Agnihotri AK, Khatoon S, Rawat AKS, Mehrotra S (2003) Pharmacognostical evaluation of an antioxidant plant—Acorus calamus. Nat Prod Sci 9:264–269
Grieve M (1971) A modern herbal, vol II. Dover Publications, Inc., New York, pp 726–729
Haghighi SR, Asadi MH, Akrami H, Baghizadeh A (2017) Anti-carcinogenic and anti-angiogenic properties of the extracts of Acorus calamus on gastric cancer cells. Avicenna J Phytomed 7:145
Hazra R, Guha D (2003) Effect of chronic administration of Acorus calamus on electrical activity and regional monoamine levels in rat brain. Biogenic Amines 17:161–169
Hosen SM, Das R, Rahim ZB, Chowdhury N, Paul L, Saha D et al (2011) Study of analgesic activity of the methanolic extract of *Acorus calamus* L. and Oroxylum indicum vent by acetic acid induced writhing method. Bull Pharm Res 1:63–67
Imam H et al (2013) Sweet flag (Acorus calamus Linn.): an incredible medicinal herb. Int J Green Pharm 7(4):288–296
Jain SP, Puri HS (1994) An ethno-medico-botanical survey of Parbati Valley in Himachal Pradesh (India). J Econ Taxon Bot 8(31994):21–327
Jabbar A, Hassan A (2010) Bronchodialatory effect of Acorus calamus (Linn.) is mediated through multiple pathways. J Ethhnopharmacol 131:471–477
Jayaraman RT, Anitha T, Joshi VD (2010) Analgesic and anticonvulsant effects of Acorus calamus roots in mice. Int J Pharm Technol Res 2:552–555
John H (n.d.) "Sweet flag" wetland Wildflowers of Illinois. Retrieved 28 January 2019
Kaleysa Raj R (1974) Screening of some indigenous plants for anthelmintic action against human Ascaris lumbricoides. Indian J Physiol Pharmacol 18:129–131
Karthiga T, Venkatalakshmi P, Vadivel V, Brindha P (2016) In-vitro anti-obesity, antioxidant and anti-inflammatory studies on the selected medicinal plants. Int J Toxicol Pharmacol Res 8:332–340
Kedar SM (n.d.) Antimicrobial properties of sweet flag" Accessed on 28 December 2013; http//: www.Indiamart.com/herbotech-pharmaceuticals/products
Khan MI (1986) Efficacy of Acorus calamus L. rhizome powder against pulse beetle (Callosobruchus chinensis L.). Pakistan. Vet Res J10:72
Khare AK, Sharma MK (1982) Experimental evaluation of antiepileptic activity of Acorus oil. J Sci Res Plant Med 3:100–103
Kirtikar KR, Basu BD (1935) Indian medicinal plants. In: Blater B, Cains JF, Mhaskar KS (eds). Dehradun, pp 2227–2229
Kirtikar KR, Basu BD (2001) Indian medicinal plants, vol 1. Latin Mohan Basu, Allahabad, pp 35–45
Koul O (1987) Antifeedant and growth inhibitory effects of calamus oil and neem oil on Spodoptera litura under laboratory conditions. Phytoparasitica 15:169–180
Kumar SS, Akram AS, Ahmed TF, Jaabir MM (2010) Phytochemical analysis and antimicrobial activity of the ethanolic extract of Acorus calamus rhizome. Orient J Chem 26:223–227
Kumar SN, Aravind SR, Sreelekha TT, Jacob J, Kumar BD (2015) Asarones from *Acorus calamus* in combination with azoles and amphotericin b: a novel synergistic combination to compete against human pathogenic candida species in-vitro. Appl Biochem Biotechnol 175:3683–3695
Lee MH, Chen YY, Tsai JW, Wang SC, Watanabe T, Tsai YC (2011) Inhibitory effect of -asarone, a component of Acorus calamus essential oil, on inhibition of adipogenesis in 3T3-L1 cells. Food Chem 126:1–7

Li J, Zhao J, Wang W, Li L, Zhang L, Zhao XF, Li SX (2017) New acorane-type sesquiterpene from Acorus calamus L. Molecules 22:529
Madan BR, Arora RB, Kapila K (1960) Anticonvulsant, antiveratrinic and antiarrhythmic actions of Acorus calamus Linn. an Indian indigenous drug. Arch Int Pharmacodyn Ther 124:201–211
Malabadi RB, Mulgund GS, Natraja K (2007) Ethnobotanical survey of medicinal plants Belgum district, Karnataka, India. J Med Aromat Plant Sci 29:70–77
Mamgain P, Singh RH (1994) Controlled clinical trial of the lekhaniya drug vaca (Acoruscalamus) in cases of Ischaemic heart diseases. J Res Ayur Siddha 15:35–51
Manikandan S, Devi RS, Srikumar R, Thangaraj R, Ayyappan R, Jegadeesh R et al (2010) In-vitro antibacterial activity of aqueous and ethanolic extracts of *Acorus calamus*. Int J Appl Biol Pharm Technol 1:1072–1075
Manju S, Chandran RP, Shaji PK, Nair GA (2013) In-vitro free radical scavenging potential of Acorus Calamus L. rhizome from Kuttanad Wetlands, Kerala, India. Int J Pharm Pharm Sci 5: 376–380
Mathur AC, Saxena BP (1975) Induction of sterility in male houseflies by vapours of Acorus calamus L. oil. Naturwissenschaften 62:576–577
Megoneitso Rao RR (1983) Ethnobotanical studies in Nagaland–4. Sixty two medicinal plants used by the Angami-Nagas. J Econ Tax Bot 4:167–172
Mehrotra S, Mishra KP, Maurya R, Srimal RC, Yadav VS, Pandey R, Singh VK (2003) Anticellular and immunosuppressive properties of ethanolic extract of Acoruscalamus rhizome. Int Immunopharmacol 3:53–61
Moholkar AL, Majumdar SM, Pandit PR, Joglekar GY (1975) Role of potassium in pharmacological activity of 50% alcoholic extract of Rubia cordifolia, Acorus calamus and Withania somnifera. J Res Indian Med 10:34–38
Motley TJ (1994) The ethnobotany of sweet flag, Acorus calamus (Araceae). Econ Bot 48(4): 397–412
Mukherjee PK (2002) Quality control of herbal drugs: an approach to evaluation of botanicals. Business Horizons, New Delhi, pp 692–694
Mukherjee PK et al (2007a) Acoruscalamus: scientific validation of ayurvedic tradition from natural resources. Pharm Biol 45(8):651–666
Mukherjee PK, Kumar V, Mal M, Houghton PJ (2007b) *Acoruscalamus*.: scientific validation of ayurvedic tradition from natural resources. Pharm Biol 45(8):651–666
Nethengwe MF, Opoku AR, Dudla PV, Madida KT, Shonhai A, Smith P et al (2012) Larvicidal, antipyretic and antiplasmodial activity of some Zulu medicinal plants. J Med Plant Res 6:1255–1262
Nigam MC, Ateeque A, Misra LN (1990) GC-MS examination of essential oil of Acorus calamus. Indian Perfum 34:282–285
Ott J (1975) Hallucinogenic plants of North America. Wingbow Press, Berkeley, pp 39, 40, 114, and 124
Özcan M, Akgül A, Chalchat JC (2002) Volatile constituents of the essential oil of Acorus calamus L. grown in Konya province (Turkey). J Essent Oil Res 14:366–368
Padalia RC, Chauhan A, Verma RS, Bisht M, Thul S, Sundaresan V (2014) Variability in rhizome volatile constituents of Acorus calamus L. from Western Himalaya. J Essent Oil Bear Plan Theory 17:32–41
Palani S, Kumar R, Parameswaran RP, Kumar BS (2010) Therapeutic efficacy Acorus calamus on acetaminophen induced nephrotoxicity and oxidative stress in male albino rats. Acta Pharm Sci 52:89–100
Patra A, Mitra AK (1981) Constituents of Acorus calamus: structure of acoramone. Carbon-13 NMR spectra of cis-and trans-asarone. J Nat Prod 44(6):668–669
Pokharel K, Dhungana BR, Tiwari KB, Shahi RB (n.d.) Antibacterial activities of some indigenous medicinal plant of Nepal. Accessed 18 June 2008. http://kiranbabutiwari.blogspot.com
Radušienė J, Judžentienė A, Pečiulytė D, Janulis V (2007) Essential oil composition and antimicrobial assay of Acorus calamus leaves from different wild populations. Plant Genet Res 5(1): 37–44

Rai R, Gupta A, Siddiqui IR, Singh J (1999) Xanthone glycoside from rhizome of Acorus calamus. Indian J Chem 38:1143–1144
Rai R, Siddiqui IR, Singh J (1998) Triterpenoid saponins from Acorus calamus. Chem Inform 29: 473–476
Rajasekharan S, Srivastava TN (1977) Ethnobotanical study on Vacha and a preliminary clinical trial on bronchial asthma. J Res Indian Med Yoga Homoeopathy 12:92–96
Raja AE, Vijayalakshmi M, Devalarao G (2009) Acorus calamus Linn.: chemistry and biology. Res J Pharm Technol 2(2):256–261
Rajput SB, Tonge MB, Mohan Karuppayil S (2014) An overview on traditional uses and pharmacological profile of Acoruscalamus Linn.(Sweet flag) and other Acorus species. Phytomedicine 21(3):268–276
Rao KP, Sreeramulu SH (1985) Ethnobotany of selected medicinal plants of Srikakulam district, Andhra Pradesh. Anc Sci Life 4(4):238
Runkel ST, Bull AF (2009 [1979]) Wildflowers of Iowa Woodlands. University of Iowa Press. Iowa City, p 119. ISBN: 9781587298844. Retrieved 13 Dec 2011
Saxena BP, Rohdendorf EB (1974) Morphological changes in Thermubia domestica under the influence of Acorus calamus oil vapours. Experientia 30:1298–1300
Saxena BP, Kaul O, Tikku K, Atal CK (1977) A new insect chemosterilant isolated from Acorus calamus L. Nature 270:512–513
Saxena DB, Tomar SS, Singh RP (1990) Fungitoxicity of chemical components and some derivatives from Anethum sowa and Acorus calamus. Indian Perfum 34(3):199–203
Shah AJ, Gilani AH (2010) Bronchodilatory effect of Acorus calamus (Linn.) is mediated through multiple pathways. J Ethnopharmacol 131(2):471–477
Sharma RD, Chaturvedi C, Tewari PV (1985) Helminthiasis in children and its treatment with indigenous drugs. Anc Sci Life 4:245–257
Shoba FG, Thomas M (2001) Study of antidiarrhoeal activity of four medicinal plants in castor-oil induced diarrhoea. J Ethnopharmacol 76:73–76
Silprasit K, Seetaha S, Pongsanarakul P, Hannongbua S, Choowongkomon K (2011) Anti-HIV-1 reverse transcriptase activities of hexane extracts from some Asian medicinal plants. J Med Plant Res 5:4194–4201
Singh D, Mehta S (1998) Screening of plant materials for repellent and insecticidal properties against pulse beetle (Callosobruchus chinensis) and housefly (Musca domestica). J Med Aromat Plant Sci 20(2):397–400; 9 ref
Singh RP, Tomar SS, Devakumar C, Goswami BK, Saxena DB (1991) Nematicidal efficacy of some essential oils against meloidogyne incognita. Indian Perfum 35:35–37
Singh R, Sharma PK, Malviya R (2011a) Pharmacological properties and ayurvedic value of Indian Buch plant (Acorus calamus): a short review. Adv Biol Res 5(3):148
Singh R, Sharma PK, Malviya R (2011b) Pharmacological properties and ayurvedic value of Indian Buch plant (*Acorus calamus*): a short review. Adv Biol Res 5:145–154
Srivastava VK, Singh BM, Negi KS, Pant KC, Suneja P (1997) Gas chromatographic examination of some aromatic plants of Uttar Pradesh hills. Indian Perfum 41(4):129–139
Stahl E, Keller K (1981) Planta Med 43(2):128–140
Subrahmanyam TV (1949) Sweet flag (Acorus calamus) a potential source of valuable insecticide. J Bombay Nat Hist Soc 48:338–341
Tripathi AK, Singh RH (1995) Clinical study on an indigenous drug vaca (Acorus calamus) in the treatment of depressive illness. J Res Ayurvedic Siddha 16:24
USDA, NRCS (2014) The PLANTS Database (http://plants.usda.gov, 29 May 2014). National Plant Data Center, Barton Rouge, LA
Vashi IG, Patel HC (1987) Chemical constituents and antimicrobial activity of Acorus calamus Linn. Comp Physiol Ecol 12:49–51
Wedeck HE (1960) The Dictionary of Aphrodisiacs. Philosophical Library, New York, p 2

Wu HS, Li YY, Weng LJ, Zhou CX, He QJ, Lou YJ (2007) A fraction of Acorus calamus L. extract devoid of-asarone enhances adipocyte differentiation in 3T3-L1 cells. Phytother Res 21:562–564

Wu HS, Zhu DF, Zhou C (2009) Insulin sensitizing activity of ethyl acetate fraction of Acorus calamus L. in vitro and in vivo. J Ethnopharmacol 123:288–292

Yao X, Ling Y, Guo S, Wu W, He S, Zhang Q, Zou M, Nandakumar KS, Chen X, Liu S (2018) Tatanan A from the Acorus calamus L root inhibited dengue virus proliferation and infections. Phytomedicine 42:258–267

Zaugg J, Eickmeier E, Ebrahimi SN, Baburin I, Hering S, Hamburger M (2011) Positive GABAA receptor modulators from Acorus calamus and structural analysis of (+)-dioxosarcoguaiacol by 1D and 2D NMR and molecular modeling. J Nat Prod 74:1437–1443